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D. González-Alonso[1,*], P. Bender[1], M. T. Fernández-Díaz[2], H. Gavilán[3], M. P. Morales[3], J. Fock[4], L. K. Bogart[5], L. Zeng[6], C. Grüttner[7], N. Gehrke[8], A. Fornara[9], L. Fernández Barquín[1], and C. Johansson[10]

[1]*Departamento CITIMAC, Universidad de Cantabria, 39005 Santander, Spain*
[2]*Institut Laue-Langevin ILL, LSS, 38042 Grenoble, France*
[3]*Instituto de Ciencia de Materiales de Madrid, CSIC, 28049 Madrid, Spain*
[4]*Technical University of Denmark, 2800 Kongens Lyngby, Denmark*
[5]*Healthcare Biomagnetics Laboratory, UCL, 21 Albemarle Street, W1S 4BS London, UK*
[6]*Department of Applied Physics, Chalmers University of Technology, SE-41296 Gothenburg, Sweden*
[7]*Micromod Partikeltechnologie GmbH, Friedrich-Barnewitz-Str. 4, D-18119 Rostock, Germany*
[8]*NanoPET Pharma GMbH, D-10115 Berlin, Germany*
[9]*RISE, Box 5607, SE-11486 Stockholm, Sweden*
[10]*RISE Acreo, P.O. Box 53071, SE-40014 Göteborg, Sweden*

Over the last years, iron-oxide nanoparticles (IONPs) have experienced an ever-increasing interest due to the range of possibilities to apply them in biomedicine such as drug delivery, contrast agents for magnetic resonance imaging, and hyperthermia in cancer treatment [1]. To achieve a successful application it is mandatory to standardise procedures and to define key structural and magnetic parameters. The only way to derive such information is to proceed characterising thoroughly the IONPs, especially when single- and multi-core nanoparticles are involved [2].

In this contribution we combine TEM, magnetization measurements, Mössbauer, X-ray and neutron diffraction results to investigate the structural and magnetic properties for a selected IONP samples regarding their size and core arrangement, e.g., Single-core, multi-core and flower shape [3]. The selected IONP samples present a median core size and particle size ranging from ca. 9 nm and ca. 50nm, up to ca. 15 and ca. 250 nm, respectively. Structural characterisation is essential to help us to interpret the static and dynamic behaviour in DC-magnetisation measurements and AC-susceptibility studies [3, 4]. The ZFC-FC measurements show a wide range of blocking temperature peaks, with the blocking temperature being substantially larger for the smaller particles. We interpret this to be the result of the smaller core-to-core distance between adjacent and the effect this has on the dipole-dipole interaction. Room temperature Mössbauer spectra show, within nano time-scale, that all samples are below their superparamagnetic blocking temperature. In addition, samples with similar core sizes exhibit different magnetic relaxation effects due to core arrangement effects, and underlying different exchange interaction between the cores suppressing the superparamagnetic relaxation of the IONPs [3, 5]. Rietveld refinement of both nuclear and magnetic structures has been carried out by using a standard inverse spinel model with a *Fd-3m* space group and surmising the samples are a mixing of a maghemite and magnetite phases. All samples reveal a ferrimagnetic behaviour. This enable us to calculate the magnetization values of our IONP samples through the neutron diffraction data measured at room temperature, which indeed are in good agreement with literature [6]. With this we obtain a complete picture of the properties that an IONP ensemble can display depending on their size and core arrangement.

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[*] galonsod@unican.es, dagal99@gmail.com